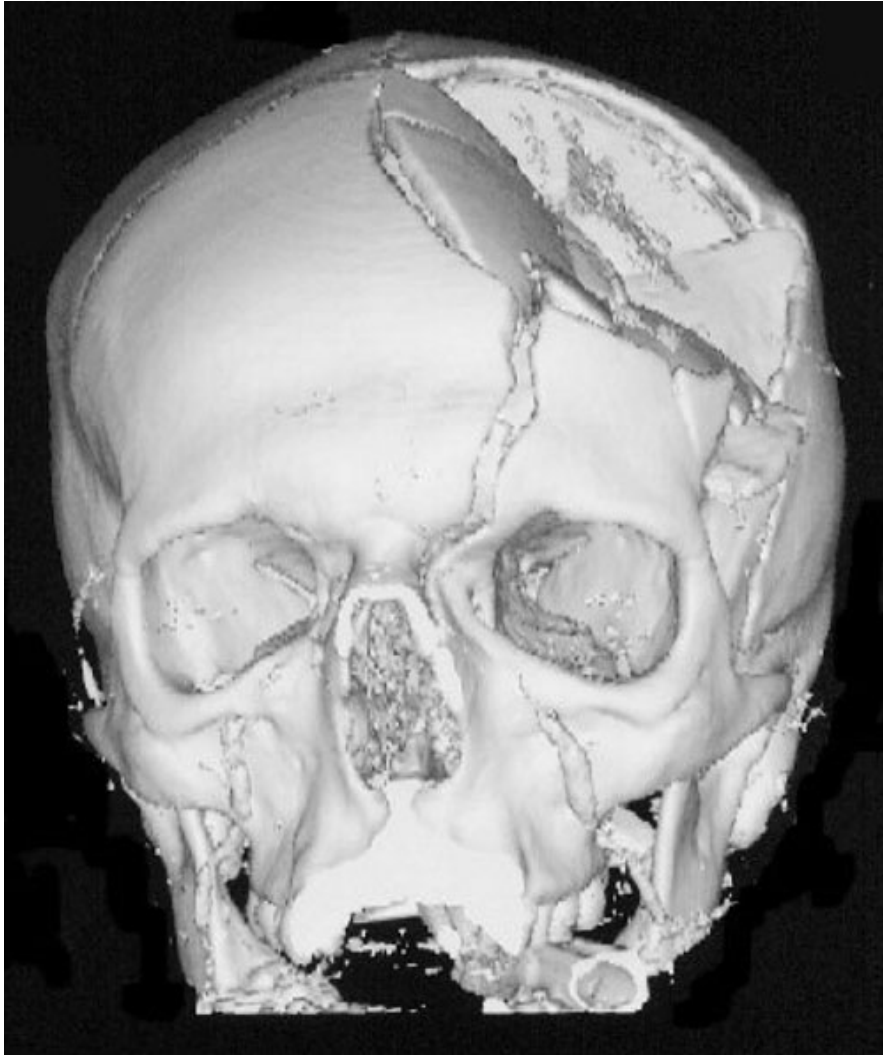


Traumatic Brain Injury



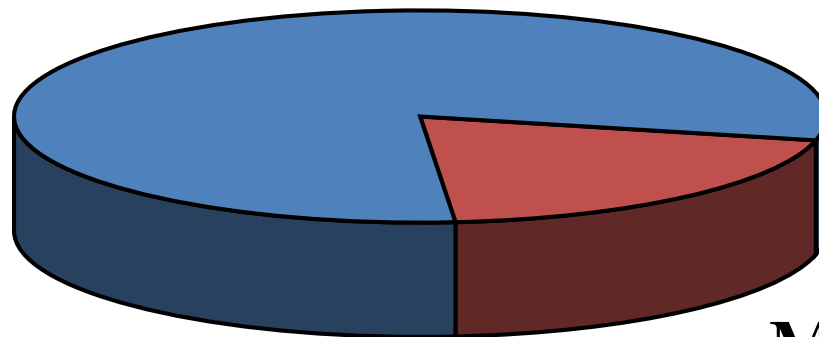
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Overview

In US HI responsible for 33% trauma deaths.

Closed HI
80%



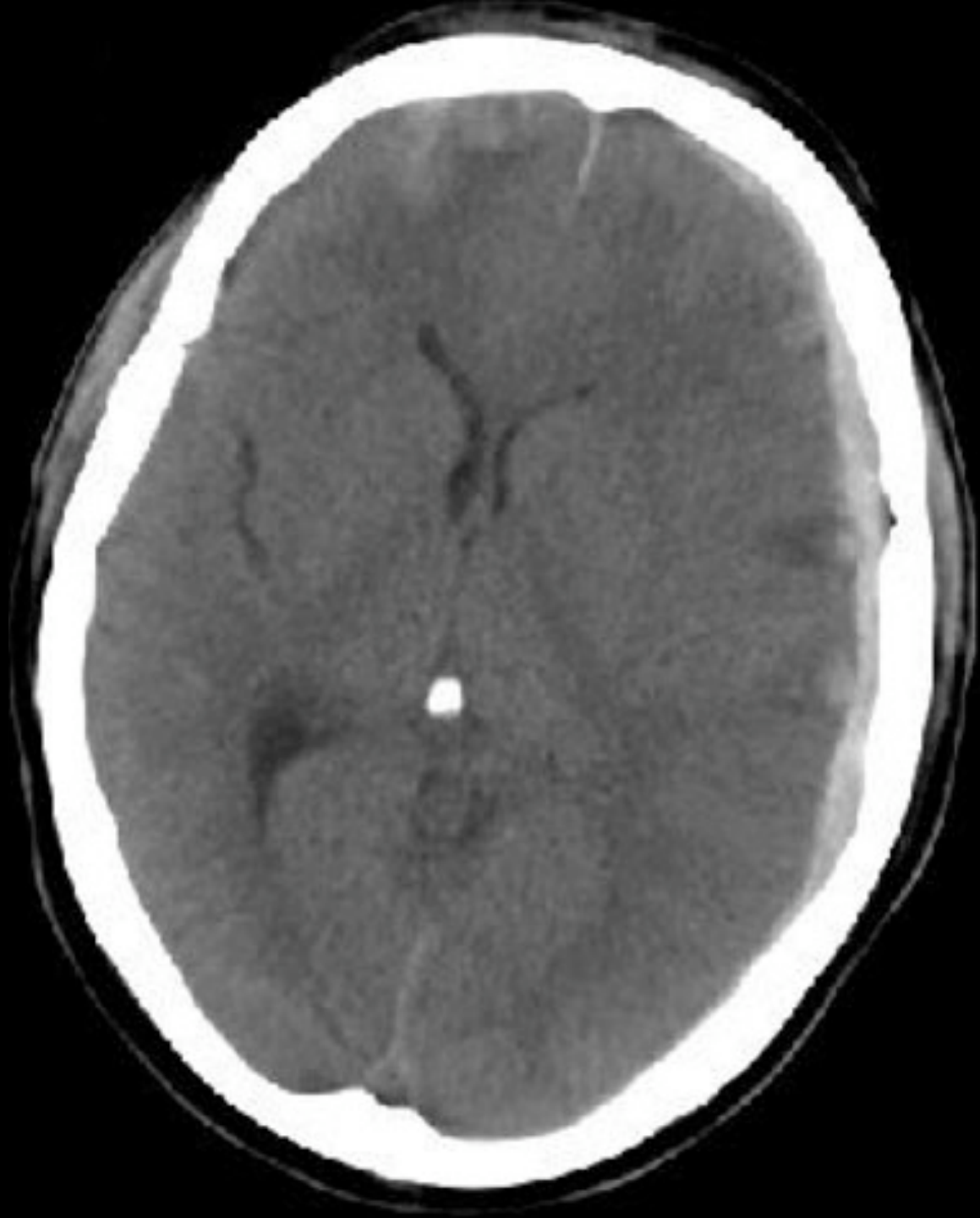
**Missile /
Penetrating
HI**
20%

Glasgow Coma Scale

Parameter	Score
Eye opening	
Spontaneous	4
To speech	3
To pain	2
None	1
Best Motor Response	
Obeys	6
Localizes	5
Withdraws	4
Abnormal flexion	3
Extensor response	2
None	1
Verbal Response	
Oriented	5
Confused conversation	4
Inappropriate words	3
Incomprehensible sounds	2
None	1

Prognosis

GCS	Injury Severity	Mortality
13 – 15	Mild	0.3 %
9 - 12	Moderate	
≤ 8	Severe	25 – 80 %



Subdural Hematoma

Most common focal intracranial lesion – 24%

Mortality 50% - brain damage from:

1. \uparrow ICP \Rightarrow \downarrow cerebral blood flow / oxygenation
2. toxic effects of blood in subdural space

Tx – prompt surgical evacuation – longer delay = more severe ischemic damage

Epidural Hematoma

- Less common – 6% of severe closed HI
- Almost always associated skull fracture
- Mortality \approx preop neurologic status:
 - no coma = 0%
 - obtunded = 9%
 - deep coma = 20%
- Tx = rapid surgical evacuation



Intracerebral Hematoma

- 10% of severe closed HI
- Can be present:
 - on initial presentation
 - delayed (24-48 hours) - often associated with clinical deterioration
- Indications for surgery controversial

Diffuse Axonal Injury

= traumatic coma > 6 hours

- No mass lesion requiring surgery
- Microscopic damage throughout the brain

Mild	coma 6-24 h duration
Moderate	coma > 24h without decerebrate posturing
Severe	coma >24h with decerebrate posturing mortality 50%

Effects of HI - Cardiopulmonary

1. Abnormal breathing patterns – from \uparrow ICP
2. Airway obstruction
3. Hypoxemia – 30-50%
4. Shock
5. Adult respiratory distress syndrome
6. Neurogenic pulmonary edema – often fatal
7. Fat embolism
8. ECG changes – uncertain mechanism
9. Diaphragmatic paralysis

Effects of HI - Endocrine

- Anterior pituitary insufficiency rare
 - e.g. GH, LH, FSH
- Posterior pituitary insufficiency:
 - Diabetes insipidus
 - usually in association with basal skull fracture
 - Syndrome of inappropriate ADH secretion
 - develops 3-15 dy after trauma – lasts 10-15 dy

DI vs SIADH

	DI	SIADH
	Inadequate ADH	Excess ADH
Pathophysiology	Neurogenic = <i>lack</i> of ADH (Nephrogenic = <i>insensitivity</i> to ADH)	
Symptoms & signs	Mental status changes weakness, lethargy, seizures, coma Dehydration, polyuria, polydipsia,	Mental status changes HA, N&V, seizures, coma Cerebral edema
	Hypernatremia Low urine osmolarity high urine output Hyperosmolarity (> 320 mOsm)	Hyponatremia (< 130 mEq/l) High urine osmolarity low urine output Hypoosmolarity (< 270 mOsm/l)
		Urine Na > 20 mEq/l Decreased BUN, Creatinine, albumin
Treatment	D5 ¹ / ₄ NS Neurogenic – vasopressin DDAVP (desmopressin) Chlorpropamide (↑release ADH)	NS, fluid restriction Demeclocycline (beware rapid correction ⇒ central pontine myelinolysis)

Effects of HI - Metabolic

- Glucose intolerance
- CSF metabolic changes
- Nonketotic hyperosmolar hyperglycemic coma
 - assoc with DI, ↑↑ICP and uniformly fatal

Effects of HI - Hematologic

DIC from:

- release of brain thromboplastin
- fat emboli
- shock
- sepsis

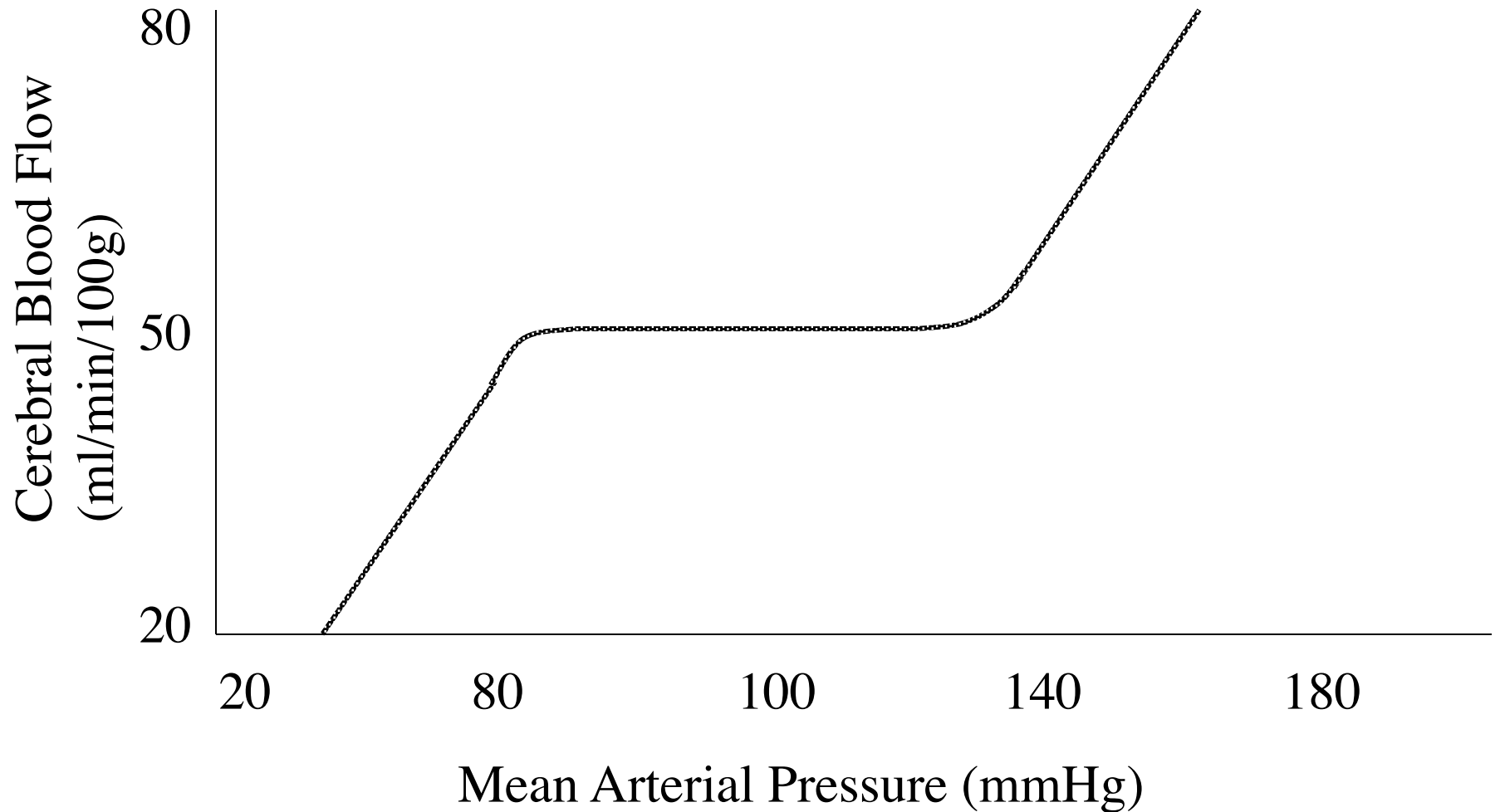
Effects of HI - Skeletal

- 20% have spinal cord injury
- Maxillofacial injuries:
 - carotid artery injury
 - vertebral artery injury
 - Horner's sy

Cerebral Perfusion Pressure

$$\text{CPP} = \text{MAP} - (\text{highest of CVP or ICP})$$

Cerebral Autoregulation



Intracranial Pressure

- Normal resting ICP = 0-15 mmHg
- Transient \uparrow with:
 - straining
 - coughing
 - position
- Sustained ICP $>$ 20 mmHg abnormal

Intracranial Pressure

20-40 mmHg = moderate intracranial HTN

>40 mmHg = severe, life-threatening

Intracranial HTN \Rightarrow global or local ischemia
(*from compression of intracranial vessels*)

If CPP < 40 mmHg \Rightarrow mortality > 90%

Anesthetic Induction

1. Airway control:
 - a) Preserve oxygenation & CO₂ elimination
 - b) Prevent aspiration
2. Maintain systemic BP to maintain CPP
 - hypotension rarely from HI alone
 - no advantage of colloid over crystalloid
 - ↓ dose of induction agent if hypovolemia suspected

Anesthetic Induction

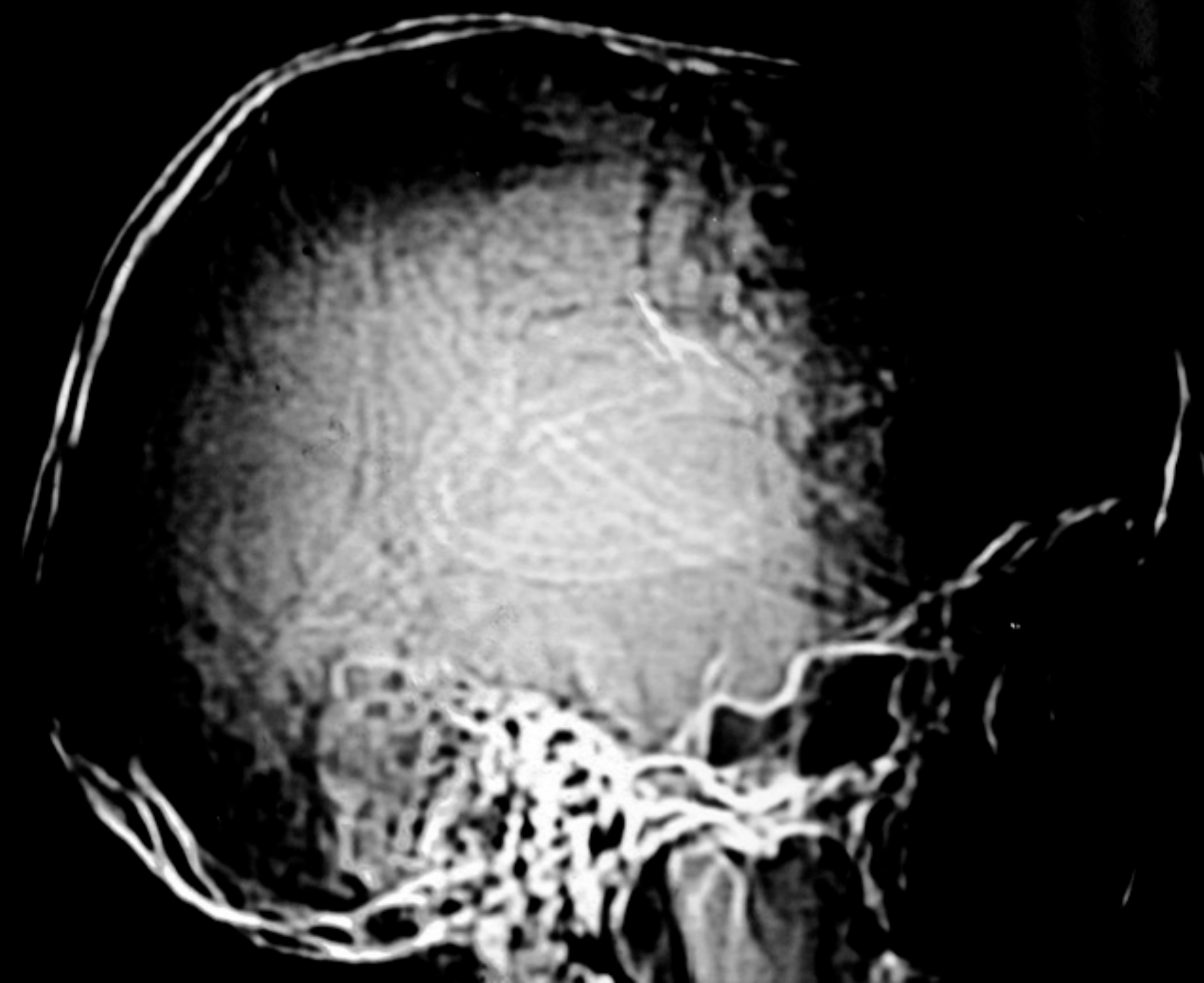
3. Minimize \uparrow in ICP – therefore:
 - controlled ventilation
 - sedation & paralysis
 - elevate head of bed 15-30° (unless hypotension)
 - mannitol for herniation / neurologic deterioration
- Monitor all pts with GCS < 8
- Only contraindication = severe coagulopathy

Anesthetic Induction

4. 10% have C-spine injury
 - obtain lateral C-spine XR before intubation (unless deep coma)
 - Manual inline axial stabilization

5. Evidence of basal skull fracture =
contraindication to nasal intubation

60
40
20
0
-20
-40
-60



Anesthetic Induction

6. Drugs to avoid :

- i. Ketamine
- ii. N₂O
- iii. Sodium nitroprusside - ↑ ICP
- iv. Hydralazine - ↑ ICP
- v. Nitroglycerine - ↑ ICP
- Corticosteroids not useful in head injury

Anesthetic Induction

7. Lidocaine can blunt response to intubation
8. Succinylcholine is appropriate after HI

Postop Concerns

Intracranial HTN 50-70% after evacuation

1. postop hematoma (old site or new site)
2. progressive swelling of focal contusion
3. diffuse brain swelling

Therefore keep ICP < 20-25 mmHg:

- hyperventilation
- mannitol
- CSF drainage
- head up position
- barbiturate coma (*beware hypotension*)

Postop Concerns

Systemic HTN can \Rightarrow \uparrow ICP / edema

Therefore keep SBP < 160 mmHg:

- Sedation
- β -blockers (e.g. propranolol, labetalol)
- α -agonists (e.g. clonidine, alpha-methyldopa)

Postop Concerns

Fever can:

- ↑ ICP
- ↑ cerebral metabolic demand
- worsen outcome

Tx with:

- antipyretics
- cooling blankets

Postop Concerns

Prophylactic
antiseizure medication
not recommended

Pediatric HI

Response	Score	Age
Eye Response		
Spontaneously	4	
To speech	3	
To pain	2	
None	1	
Best Motor response in upper limbs		
Obeys commands	6	>2 years
Localizes to pain	5	6 months – 2 years
Normal flexion to pain	4	>6 months
Spastic flexion to pain	3	<6 months
Extension to pain	2	
None	1	
Best verbal response		
Oriented to place	5	>5 years
Words	4	>12 months
Vocal sounds	3	>6 months
Cries	2	<6 months
None	1	

Pediatric HI

In infants
systemic hypotension
can result from
brain injury alone

Pediatric HI

- Epidural hematoma less common in children
- Diffuse brain swelling more common
Tx = control ICP:
 - Hyperventilation
 - Prevent hypoxia - maintain normal Hb and BP